Appendix VI

Methodology for Estimating the Ambient Concentrations of Particulate Matter from Diesel-Fueled Engines and Vehicles

October 2000

I. PURPOSE

The purpose of this section is to present our methodology for updating the estimates for the statewide population-weighted annual outdoor average diesel PM concentration.

II. INTRODUCTION

The concentration of diesel PM that most Californians may be exposed to is estimated by the statewide population-weighted annual outdoor average diesel PM concentration. The Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part A, Exposure Assessment[1] (ID Report) reported the statewide population-weighted annual outdoor average diesel PM concentration as 3.0 $\mu g/m^3$ for 1990. The ARB staff used studies from the San Joaquin Valley, South Coast, and San Jose to obtain speciated PM_{10} ambient data, along with ambient PM_{10} monitoring network data, and the 1990 PM_{10} emissions inventory, in a receptor model approach to estimate the statewide outdoor concentration of diesel PM.

III. METHODOLOGY

A. Basic Approach

We determined the ratio of the estimated statewide population-weighted annual outdoor average diesel PM concentration for 1990 from the ID Report and the most recent diesel PM emission inventory for the year 1990.

$\underline{3.0 \ \mu g/m^3}$ (year 1990 statewide diesel PM concentration)
46,400 TPY (1990 diesel PM emissions inventory)

We then established the following equation:

$$\frac{3.0 \ \mu g/m^3 \quad (1990)}{46,400 \ \text{TPY} \quad (1990)} = \frac{x \ \mu g/m^3 \quad (2000)}{28,000 \ \text{TPY} \ (2000)}$$

We then multiplied the year 2000 updated emission inventory estimate by (3.0 $\mu g/m^3$/46,400 TPY) to obtain the year 2000 statewide population-weighted annual outdoor average diesel PM concentration.

B. The Baseline

As stated above, the ID Report reported the statewide population-weighted annual outdoor average diesel PM concentration as 3.0 $\mu g/m^3$ for 1990. This estimate was determined using receptor modeling techniques, including chemical mass balance

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[1] As approved by the Scientific Review Panel on April 22, 1998.

model results from several studies, ambient 1990 PM_{10} monitoring network data, and 1990 PM_{10} emissions inventory data to estimate Californians' outdoor ambient exposures to diesel PM. The 1990 PM_{10} inventory and ambient monitoring data were used as the basis for calculating the statewide exposure to diesel PM because it better represented the emission sources in the years when the ambient data were collected for the studies used to estimate 1990 diesel PM outdoor concentrations.

C.   Revised Estimates

The emissions inventory is updated continuously. The categories of the emissions inventory include: stationary source, area sources, and mobile sources. The emissions inventory also includes natural (non-anthropogenic) sources.

Originally, the emissions inventory did not include a complete inventory of off-road equipment. Recently, we have worked to update the off-road diesel engine inventory. Portable equipment has been included as a subset of the off-road emissions inventory. The methodology used to develop the inventory for off-road engines including portable engines is presented in Appendix III. Typical categories in the off-road emissions inventory include: agricultural engines, construction equipment, and military tactical support equipment.

In addition to underestimating emissions from off-road equipment, previous emission inventories underestimated emissions from diesel-fueled stationary engines by underrepresenting the number of stationary engines. Because of this concern, we have performed a more detailed inventory of stationary diesel engines along with better estimates of the stationary source contribution to diesel exhaust emissions. The methodology used to develop the inventory for stationary engines is presented in Appendix II.

As a result of the additional work to update the emissions inventory, the revised estimate for the total statewide diesel PM emissions inventory for 1990 is 46,400 TPY. The estimated emissions of diesel PM in California for the years 1990, 2000, 2010, and 2020 are as presented in Tables 1, 2, 3, and 4.

**Table 1: Estimated Statewide Diesel PM Emissions Inventory –
Diesel-Fueled Engines and Vehicles (1990)**

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,600	400	0.9
Emergency Stand-by	10,200	124	0.3
MOBILE			
On-road	606,700	18,400	39.7
Off-road (Excluding Portable Equipment)	476,300	25,300	54.5
Portable	47,600	2,200	4.7
TOTAL	**1,145,300**	**46,400**	**100.0***

* may not add to 100% due to rounding

**Table 2: Estimated Statewide Diesel PM Emissions Inventory –
Diesel-Fueled Equipment and Vehicles (2000)**

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,800	420	1.5
Emergency Stand-by	11,300	138	0.5
MOBILE			
On-road	687,200	7,500	26.8
Off-road (Excluding Potable Equipment)	498,200	18,500	66.1
Portable	49,200	1,400	5.0
TOTAL	**1,250,700**	**28,000**	**100.0 ***

* may not add to 100% due to rounding

**Table 3: Estimated Statewide Diesel PM Emissions Inventory –
Diesel-Fueled Equipment and Vehicles (2010)**

Category	Engine Population	diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,400	360	1.6
Emergency/Standby	12,300	143	0.6
MOBILE			
On-road	643,900	5,200	22.9
Off-road (Excluding Potable Equipment)	521,300	15,900	70.0
Portable	53,600	1,100	4.8
TOTAL	**1,235,500**	**22,700**	**100.0 ***

* may not add to 100% due to rounding

**Table 4: Estimated Statewide Diesel PM Emissions Inventory –
Diesel-Fueled Equipment and Vehicles (2020)**

Category	Engine Population	diesel PM (tons per year)	% of Total diesel PM Emissions
STATIONARY			
Prime	4,400	350	1.9
Emergency Stand-by	13,200	149	0.8
MOBILE			
On-road	610,200	4,900	26.0
Off-road (Excluding Potable Equipment)	527,800	12,800	67.9
Portable	55,200	660	3.5
TOTAL	**1,210,800**	**18,900**	**100.0 ***

* may not add to 100% due to rounding

The statewide population-weighted annual outdoor average diesel PM concentration was estimated at 3.0 $\mu g/m^3$ in 1990. We are assuming that the ratio between the statewide population-weighted annual outdoor average diesel PM concentration and statewide emissions remains constant.

Applying the ratio (3.0 $\mu g/m^3$/46,400 TPY) to the updated year 2000 statewide

emissions of 28,000 TPY yields an updated statewide population-weighted annual outdoor average diesel PM concentration of 1.8 µg/m^3.

$$\frac{3.0 \ \mu g/m^3 \quad (1990)}{46,400 \text{TPY} \quad (1990)} = \frac{x \ \mu g/m^3 \quad (2000)}{28,000 \text{ TPY} \ (2000)}$$

The same ratio can be applied to the updated statewide concentration estimates for the years 2010 and 2020 to estimate the statewide population-weighted annual outdoor average diesel PM concentrations for those years. (See Table 4.)

Table 4: Updated statewide population-weighted annual outdoor average diesel PM concentrations for 2000, 2010, and 2020

Year	2000	2010	2020
Emissions (TPY)	28,000	22,700	18,900
Concentration (µg/m^3)	1.8	1.5	1.2
Risk (cancers/million)	540	450	360

D.   Cancer Risk Associated with the Updated Statewide Population-Weighted Annual Outdoor Average Diesel PM Concentration

The Office of Environmental Health Hazard Assessment (OEHHA) reviewed and evaluated the potential for diesel exhaust to affect human health, and the associated scientific uncertainties. They considered acute and chronic noncancer health impacts, and potential cancer health impacts. The Scientific Review Panel (SRP) approved the OEHHA's health assessment at their April 22, 1998, meeting.

Based on available scientific evidence, a level of diesel PM exposure below which no carcinogenic effects are anticipated has not been identified. This finding was also approved by the SRP at their April 22, 1998 meeting.

The estimated range of lung cancer risk (upper 95% confidence interval) based on human epidemiological data is 1.3×10^{-4} to 2.4×10^{-3} (µg/m^3)$^{-1}$. After considering the results of human studies and detailed analysis of railroad workers, the SRP concluded that 3×10^{-4} (µg/m^3)$^{-1}$ is a reasonable estimate of unit risk expressed in terms of diesel PM.

This reasonable estimate of 3 x 10^{-4} $(\mu g/m^3)^{-1}$ means that a person exposed to a concentration of 1 $\mu g/m^3$ of diesel PM has a 3 per 10,000 chance of contracting cancer in their lifetime. Three per 10,000 chances is the same as a 300 per million chances.

For Californians exposed to an annual outdoor average diesel PM concentration of 1.8 $\mu g/m^3$, the risk of contracting cancer from exposure to diesel PM is 540 chances per million during a lifetime. (See Table 5.)

Table 5:
Updated Statewide Outdoor Diesel PM Concentrations and Cancer Risk

Year	Statewide Diesel PM in California (TPY)	Statewide Population–Weighted Annual Outdoor Average Diesel PM Concentration ($\mu g/m^3$)	Statewide Cancer Risk (cancers/million)
1990	46,400	3.0	900
2000	28,000	1.8	540
2010	22,700	1.5	450
2020	18,900	1.2	360

E.   Indoor and Total Air Exposure

The ID Report provided estimates of indoor and total exposure to diesel PM. ARB staff used estimates of population-weighted annual outdoor average diesel PM concentrations for 1990 in the California Population Indoor Exposure Model (CPIEM). The resulting indoor exposure estimate was approximately two-thirds of the population-weighted annual outdoor average diesel PM concentration. In the ID Report, the 1990 ratio was then applied to the estimated population-weighted annual outdoor average diesel PM concentrations for 1995, 2000, 2010 and 2020. In this report, we applied the same indoor/outdoor ratio to the updated statewide diesel PM concentrations. (See Table 6.)

Table 6:
Estimated Exposure of Californians to Diesel PM for 2000, 2010, and 2020

| | Estimated Average Air Exposure Concentration – 1990 $\mu g/m^3$ | 1990 Ratio | Estimated Average Air Exposure Concentration ($\mu g/m^3$) and Risk (excess cancers/million) | | | | | |
| | | | 2000 | | 2010 | | 2020 | |
			Conc.	Risk	Conc.	Risk	Conc.	Risk
Outdoor Ambient Estimate	3.0		1.8	540	1.5	450	1.2	360
Total Indoor Exposure Estimate	2.0	2.0/3.0	1.2	360	1.0	300	0.80	240
Total Exposure Estimate	2.1	2.1/3.0	1.26	380	1.05	315	0.84	252